

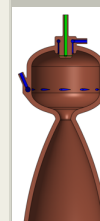
Additively Manufactured Monolithic LOx/Methane Vortex RCS Thruster, Phase I

Completed Technology Project (2015 - 2015)



Project Introduction

Parabilis Space Technologies (Parabilis), in collaboration with Orbital Technologies Corporation (ORBITEC), proposes to use additive manufacturing technology to fabricate a complete liquid oxygen (lox) and liquid methane Reaction Control System (RCS) thruster in response to solicitation H2.01, In-Space Chemical Propulsion. The thruster will be fabricated as a monolithic part that includes the injectors, combustion chamber, and nozzle. This thruster design will leverage a propulsion architecture especially amenable to additive manufacturing: ORBITEC's revolutionary Vortex Combustion Cold-Wall (VCCW) technology. Through additive manufacturing, Parabilis will reduce the cost, increase reliability, decrease complexity, and significantly reduce CAD-to-part design cycle time. Lox-methane is an attractive propellant combination for future NASA missions, however significant technical challenges remain. This proposed innovation provides novel solutions to challenges for lox-methane rocket engines as requested by the H2.01 solicitation. Specifically, this proposal includes innovations for RCS class thrusters, including advances in additive manufacturing, propellant injectors, and combustion chamber design. Additionally, the use of VCCW technology will likely mitigate adverse effects of multiphase or intermittent gas phase operation. Due to the low wall temperatures inherent to VCCW technology, the proposed thruster will provide almost no additional thermal loading to the main vehicle structure. The proposed thruster should obtain a vacuum specific impulse significantly in excess of 325 s for vacuum operation. Phase I development objectives include preliminary design of the thruster and cold flow testing of a thruster prototype that will be used to test the applicability of several additive manufacturing techniques. By the end of Phase I testing the technology will be at a TRL 4 level.



Additively Manufactured Monolithic LOx/Methane Vortex RCS Thruster



Additively Manufactured Monolithic LOx/Methane Vortex RCS Thruster, Phase I

Table of Contents

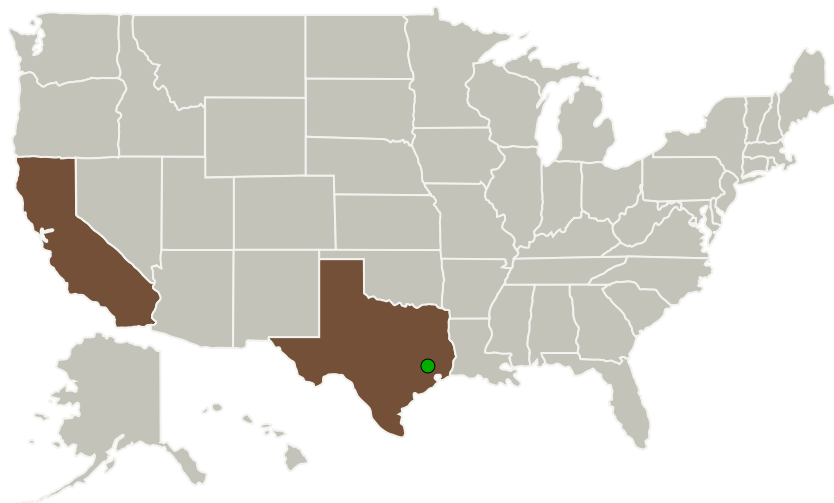
| | |
|--|---|
| Project Introduction | 1 |
| Primary U.S. Work Locations and Key Partners | 2 |
| Project Transitions | 2 |
| Organizational Responsibility | 2 |
| Project Management | 2 |
| Technology Maturity (TRL) | 2 |
| Images | 3 |
| Technology Areas | 3 |
| Target Destinations | 3 |

Additively Manufactured Monolithic LOx/Methane Vortex RCS Thruster, Phase I

Completed Technology Project (2015 - 2015)



Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|------------------------------------|-------------------------|--|------------------------|
| Parabilis Space Technologies, Inc. | Lead Organization | Industry Historically Underutilized Business Zones (HUBZones) | SAN MARCOS, California |
| ● Johnson Space Center(JSC) | Supporting Organization | NASA Center | Houston, Texas |

Primary U.S. Work Locations

| | |
|------------|-------|
| California | Texas |
|------------|-------|

Project Transitions

▶ **June 2015:** Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Parabilis Space Technologies, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

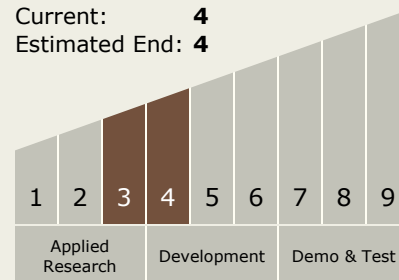
Carlos Torrez

Principal Investigator:

Christopher S Grainger

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



Additively Manufactured Monolithic LOx/Methane Vortex RCS Thruster, Phase I

Completed Technology Project (2015 - 2015)



✓ **December 2015:** Closed out

Closeout Summary: Additively Manufactured Monolithic LOx/Methane Vortex RCS Thruster, Phase I Project Image

Closeout Documentation:

- Final Summary Chart Image(<https://techport.nasa.gov/file/138659>)

Images



Briefing Chart Image

Additively Manufactured Monolithic LOx/Methane Vortex RCS Thruster, Phase I
(<https://techport.nasa.gov/image/132623>)

Technology Areas

Primary:

- TX01 Propulsion Systems
 - └ TX01.2 Electric Space Propulsion
 - └ TX01.2.1 Integrated Systems and Ancillary Technologies

Target Destinations

Earth, The Moon, Others Inside the Solar System, Outside the Solar System, The Sun, Mars